Use of Military Aviation Assets for Restoration of Grasslands and Forests

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Grasslands Situation

- Grasslands occupy 30-50% of the world's land area
- Ecologically and economically as important as rain forests
- In greater danger of degradation and disappearance than rain forests
- ~ 2/3 of the recent loss of grasslands has been in Africa and Asia
- Adverse environmental and societal impacts
- Climate change

Forests Situation

- Forests occupy approximately 27% of the world's land area
- Include a wide variety of forest types – from tropical to boreal
- Disappearing at a rate of ~ 0.22% per year since 1990
- Adverse environmental and societal impacts
- Climate change

Impacts of Loss

- Run off
- Erosion
- Siltation of waterways
- Disruption of hydrological cycles and evapotranspiration
- Decreased productivity
- Malnutrition
- Encroachment of deserts
- Societal instability and conflict
- Reduced removal of CO_2 by vegetation

Solution

- Mapping of target areas using satellite imagery
- DSS and ES for targeting and prioritization
- Military or other aviation assets for delivery
- Flight paths controlled by GIS/GPS software or flagging
- Grasslands 1° and forests 2°

Solution

- Seed pellets and projectiles produced locally
- Indigenous species, resources and labor
- Planting in a sequence that mimics or promotes natural succession
- Simple machinery, redeployable

Benefits

- Soil stabilization
- Improve local hydrology
- Reduce erosion and sedimentation
- Grasslands and forests for indigenous peoples
- Rangelands for forage and fodder
- Timber, charcoal, fruits and nuts

Benefits

- Biodiversity
- Increase CO_2 uptake
- Reverse or halt desertification
- Grasslands as preliminary step to reforestation
- Tourism and recreation
- Stabilization of vulnerable societies

Why the Interest ?

- Three years in Pakistan performing EIAs for power projects
- Much deforestation and erosion observed elsewhere, including
  - Sub-Saharan Africa
  - India
  - Nepal
  - Philippines
  - US
- A least-cost “hearts and minds” approach

Forests of the World

First Thoughts
Reforestation Projectiles

Aerial Reforestation and Afforestation

- Past work not particularly successful
- Projectiles and seed spheres
- Substrate typically too variable
- Projectiles shatter, damage seed, seeding or rootball
- Pick an easier target for early success
- Mangroves
- Further work required for upland species

Problems With Projectiles

- Must strike perpendicular to Earth
- Rocks and soil inconsistencies damage projectile
- Variable penetration
- Low survivorship

Discovery Channel
Project Earth – "Raining Forests"

- Originally targeted on coniferous trees
- Change in team and targets
- Redirected to mangroves
- Overcame concerns about substrate
- Louisiana coastline
- High profile target

http://dsc.discovery.com/tv/project-earth/lab-books/reforestation/reforestation-guide1.html

Mangrove Distribution

Mangroves

Projectile Field Testing System

Projectile Field Testing System

Propagule Canisters

- Dr. Howard J. Teas
  - Soil and paper bags
- M. Hodges
  - Deformable, biodegradable canisters

Mangrove Canisters

Test Drops from Skyvan

Initial Delivery System
Bambi Buckets

Discovery Channel, “Raining Forests” Aircraft

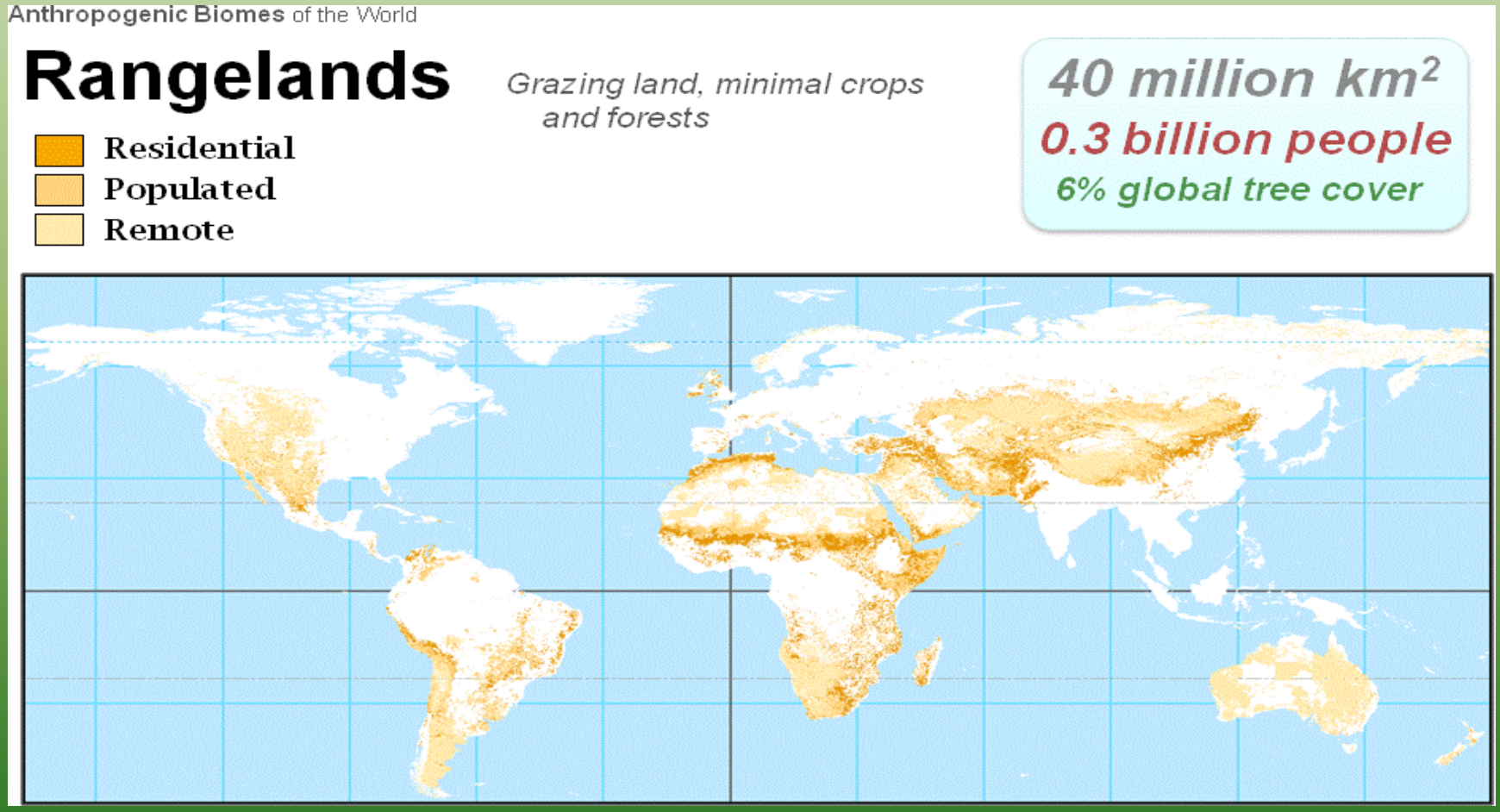
Initial Drop on Trinity Island, LA

Proper Orientation and Cratering

Lessons from “Raining Forests”

- Dealing with media is a case of “science meets circus” – use for PR, awareness and networking
- Systematic approach to siting and technologies is essential
- Soil testing is essential
- Create receptive environment
- Assist or accelerate nature

Residential, Populated and Remote Rangelands of the World



Grasslands Loss Rates

(WRI, 2000)

More Croplands, Fewer Grasslands

Figure 1: Estimated Remaining and Converted Grassland (percent)

CONTINENT AND REGION	Remaining in Grasslands	Converted to Croplands	Converted to Urban Areas	Total Converted
N. America Tallgrass Prairie in the United States	9.4	71.2	18.7	89.9
S. America Cerrado Woodland and Savanna in Brazil, Brazil, Paraguay and Bolivia	21.0	71.0	5.0	76.0
Asia Daurian Steppe in Mongolia, Russia and China	71.7	19.9	1.5	21.4
Africa Central and eastern Mopane and Miombo in Tanzania, Rwanda, Burundi, Dem. Rep. Congo, Zambia, Botswana, Zimbabwe and Mozambique	73.3	19.1	0.4	19.5
Oceania Southwest Australian shrublands and woodlands	56.7	37.2	1.8	39.0

Source: White et al. [PAGE] 2000

Ground-Based Methods

- Trees
  - Pioneer plantings
  - Natural seeding and runners
  - Hand planting of seed or seedlings
  - Tractor-towed planter with seed or seedlings
  - Mechanical, boomed planter with magazine feeds
- Grasses
  - Broadcasting, with or without cover
  - Succession

Aerial Methods

- Seedlings (trees and shrubs)
  - Projectiles
- Propagules (mangroves)
  - Canisters
  - Projectiles
- Seed (grasses and other groundcover)
  - Broadcasting of raw seed
  - Pellets

History of Proposed Aerial Methods

- Grasslands and rangelands
  - Dr. Lytle Adams
  - Dr. Masanobu Fukuoka (The One Straw Revolution)
- Forests
  - Unk., RVN, Mekong River
  - Dr. Jack Walters, BC (deceased)
  - Dr. Howard Teas, Miami University (ret'd)
  - Moshe Alamaro., MIT
  - Mark Hodges, Discovery Channel, "Raining Forests"
    http://dsc.discovery.com/tv/project-earth/lab-books/reforestation/reforestation-guide1.html

Grasslands - Seed Pellets

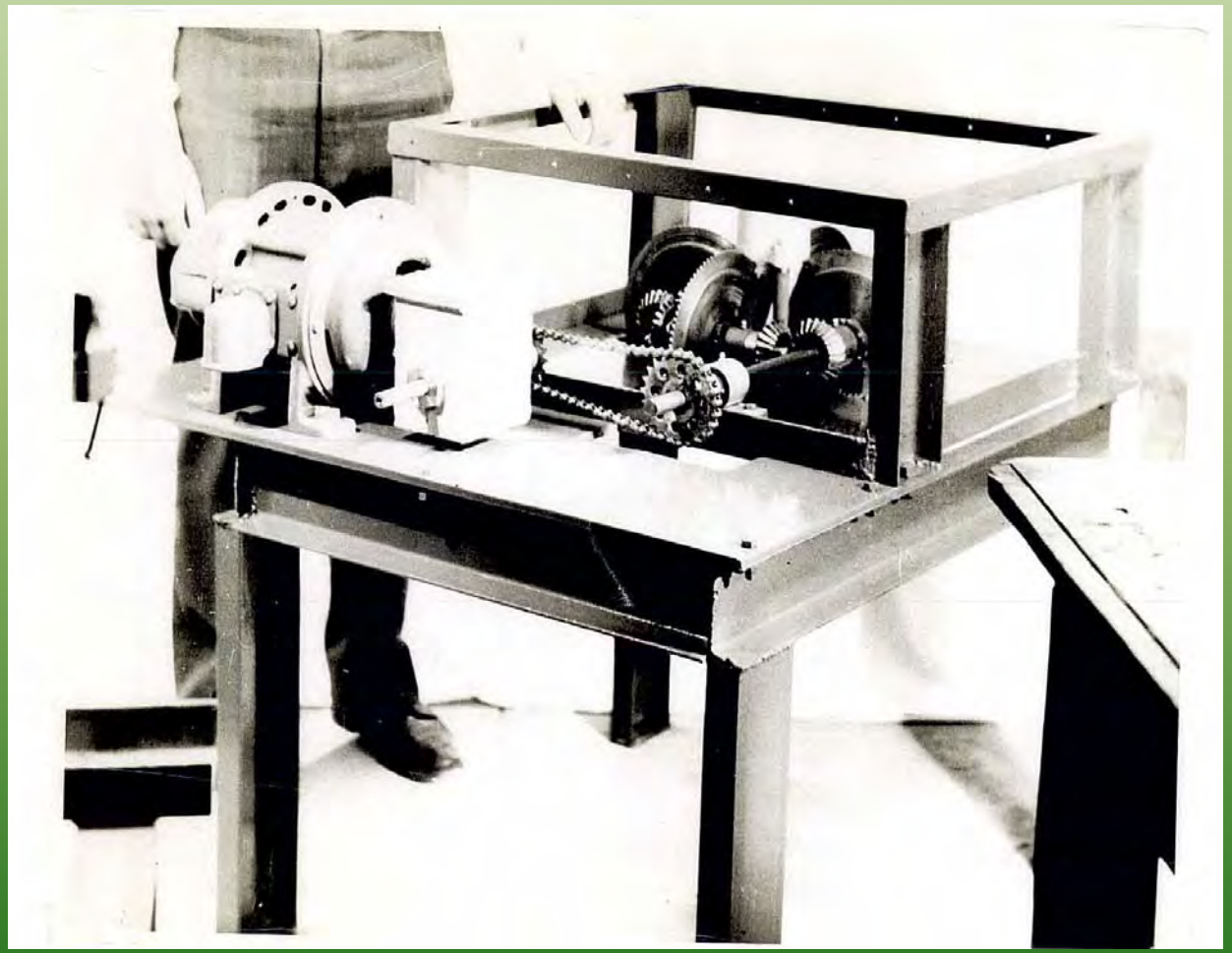
- 10 mm diameter
- 1 gram weight, pulverized soil, slow release fertilizer, natural fungicides, seeds
- Dormant until rainfall
- Viable up to 50+ years
- Not eaten by birds or other animals
- 1,000 pounds = 454,000 pellets
- At 1 pellet/ft^2 1,000 pounds = > 10 acres

Seed Pellets

- Dr. Lytle Adams
  - Universal Seed Pellets
  - Pellets for Peace
  - Successfully sowed > 170,000 acres of Navajo, Hopi and Popago rangeland in US desert SW
  - Original machine produced ~ 60,000/hour
  - Interchangeable wheels, 3 pellet diameters

Dr. Lytle Adam’s Seed Pellets

Pelletizing Machine
circa 1946



Base Camp
Desert Southwest

Delivery

Site-Specific Integrated Plan

- Thorough site investigation
- Determine desired results over time and at endpoint
- Determine cause of deforestation or loss of grasslands
- Determine corrective measures required
- Develop plan to accelerate or leap-frog nature

Computerized Approach

- **Geospatial mapping**
  - Soils and substrates
  - Hydrology
  - Civil works required
  - Species
  - Season
  - Geopolitics
  - Exclusion zones
- **Decision Support or Expert System**
  - Priority
  - Design
  - Technical (assets, mechanical, logistics, fatal flaws)
  - Financial, least cost (costs/benefits)
  - Economic (longer term and regional)

Tools - Grasslands

- http://www.unccd.int/
- http://earthtrends.wri.org/text/forests-grasslands-drylands/feature-8.html
- http://www.wri.org/publication/pilot-analysis-global-ecosystems-grassland-ecosystems
- http://www.cgiar.org/impact/global/desertification_factsheet_index.html
- http://www.blueplanetbiomes.org/grasslands.htm

Tools - Forests

- http://www.unep-wcmc.org/forest/global_map.htm
- http://www.wri.org/project/global-forest-watch
- http://www.mangroveactionproject.org/
- http://www.friendsofgaviotas.org/Gaviotas_Forest/Gaviotas_Forest.html

Academia

- University of Florida, IFAS
  http://www.ifas.ufl.edu/
- Texas A&M University, Borlaug Institute
  http://borlaug.tamu.edu/

Suitable Fixed Wing Aircraft

Private Sector Aircraft
Air Tractor AT-802

Suitable Rotary Wing Aircraft

Small Scale Aerial Delivery (CONAMA, Mexico)

Other Aircraft

- Soviet and Russian operational analogs
- Commercial

Capacity, Cost and Range Comparisons

Aircraft	Payload (lbs)	Range (miles)	$ Cost/Hr. Published rates (2009)	Number Produced (Introduced)
UH-1	~ 1,600	~ 300	1,900	9,800 (1962)
UH-60	~ 2,600 (8,000-9,000 sling load)	~360	~ 5,000	2,600 (1979)
CH-47	~ 16,000 internal (~ 25,000 sling load)	~ 450	9,800	1,179 (1962)
C-23	4,400	770-1,185	2,476	43 (1982)
C-130	45,000	~ 2300	~ 7,000	2,300 (1956)
AT-802	6,000	?	1,500	(1990)

Delivery Mechanisms

- Fixed wing
  - Internal hopper(s) only, rotary, belt or nozzle feed
- Rotary wing
  - Internal hopper(s) only, rotary, belt or nozzle feed
  - Sling load
    - Higher payload, if sling load capable
    - One delivery device can be reloaded while other is in use
    - Landing not necessary, unhook, hook, go

Estimated Costs - Grasslands

Parameter	Aircraft Delivery of Seed Pellets					
	CH-47	UH-60	UH-1	C-130	C-23	AT-802
$/hr	9,800	5,000	1,900	7,000	2,500	1,500
$/canister	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Payload (lbs)	26,000	8,000	1,500	45,000	4,400	6,000
Canisters/load	11,804,000	3,632,000	681,000	20,430,000	1,997,600	2,724,000
Acres/load (1)	271.36	83.49	15.66	469.66	45.92	62.62
Loads/day (2)	4.00	4.00	4.00	4.00	4.00	4.00
Acres/day	1,085.43	333.98	62.62	1,878.62	183.69	250.48
$/day labor (expat)	4,500	4,500	4,500	4,500	4,500	4,500
$/day labor (local)	1,500	500	500	1,500	500	500
$/acre planted (2)	100	156	344	55	158	90
$/acre planted (3)	27	37	102	25	49	42

(1) One pellet weighs 1 gram and is 3/8" in diameter

(2) Aircraft cost included

(3) Aircraft cost not included

Estimated Costs - Mangroves

Parameter	Aircraft Delivery of Mangroves					
	CH-47	UH-60	UH-1	C-130	C-23	AT-802
$/hr	9,800	5,000	1,900	7,000	2,500	1,000
$/canister	0.1	0.1	0.1	0.1	0.1	0.1
Payload (lbs)	26,000	8,000	1,500	45,000	4,400	6,000
Canisters/load	83,200	25,600	4,800	144,000	14,080	19,200
Acres/load (1)	7.65	2.35	0.44	13.24	1.29	1.77
Loads/day (2)	4.00	4.00	4.00	4.00	4.00	4.00
Acres/day	30.60	9.42	1.77	52.97	5.18	7.06
$/day labor (expat)	4,500	4,500	4,500	4,500	4,500	4,500
$/day labor (local)	1,500	1,500	1,500	1,500	1,500	1,500
$/acre planted (2)	3,845	5,973	13,095	2,258	6,108	3,070
$/acre planted (3)	1,284	1,725	4,486	1,201	2,246	1,937

(1) One canister/pellet/4ft^2, ~ 3.5" diameter and 5 oz. ea.

(2) Aircraft cost included

(3) Aircraft cost not included

Carbon Credits

- Highly variable
  - Plants
  - Soils
  - Climate
  - Method of estimation
- 15-20 years until “break-even” on cost vs. ROI

UXO

Thales Cress as UXO Locator

Targets

- Restoration of active and closed military facilities
- Restoration of conflict-related damage
- Grasslands and rangelands as endpoints
- Grasslands as first step to reforestation
- Hearts and minds
- UXO detection

Possible Sources of Funding

- DoD
- USAID
- MCC
- United Nations EP (Billion Tree Program)
- The World Bank
- Asian Development Bank
- Governments
- Remediation/restoration
- Livestock industry
- Private investors, CO2eq credits

WARNINGS

- If plants aren't growing on the site – there's a reason – will that reason cause your project to fail if not corrected?
- Beware "Knowledge overload, wisdom underload", Robin Lewis, III, Ecological Engineering, 35 (2009), pp. 341-342

http://www.mangroveactionproject.org/news/current_headlines/editorial-knowledge-overload-wisdom-underload/

QUESTIONS ?

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